

CLAIMS

What is claimed is:

1. A method for imaging an object, comprising the steps of:

directing one part of a low coherence optical radiation towards an object through an
5 optical system, which ensures focusing the low coherence optical radiation onto the object;

scanning the low coherence optical radiation being directed towards the object over a
transverse scanning surface, that is approximately orthogonal to the direction of propagation of
said optical radiation, in compliance with a predetermined rule;

providing a constant propagation time for the low coherence optical radiation propagating
10 from a given point of the transverse scanning surface to a corresponding conjugate point of the
image plane, thereby eliminating the transverse scanning related aberration of the optical path
length for the low coherence optical radiation directed towards the object;

directing another part of the low coherence optical radiation along a reference optical
path, and

15 combining the optical radiation having returned from the object with the optical radiation
that passed through the reference optical path;

visualizing the intensity of the optical radiation having returned from the object using for
that the optical radiation that is a result of the combining.

2. A method as claimed in claim 1, further comprising the step of longitudinal scanning
20 by varying the difference between the optical path lengths for the low coherence optical radiation
directed towards the object and low coherence optical radiation directed along the reference
optical path, said longitudinal scanning being performed for given coordinates in the transverse
scanning surface in compliance with a predetermined rule.

3. A method as claimed in claim 2, wherein the difference between the optical path
25 lengths for the low coherence optical radiation directed towards the object and low coherence
optical radiation directed along the reference path is varied by at least several tens of wavelengths
of the low coherence optical radiation.

4. A method as claimed in claim 2, wherein the difference between the optical path lengths is varied by altering the optical path length for the low coherence radiation propagating from the transverse scanning surface to the optical system.

5. A method as claimed in claim 1, wherein the object is a biological tissue of a living body.

6. A method as claimed in claim 5, wherein the object is an internal cavity of a living body.

7. A method as claimed in claim 1, wherein the low coherence optical radiation is an optical radiation in the visible or near infrared range.

8. An apparatus for imaging an object comprising:
a source of low coherence optical radiation;
an interferometer including a beam splitter optically coupled with a measuring arm and a reference arm;

at least one photodetector connected with a data processing and displaying unit;
the measuring arm being provided with a delivering device for low coherence optical radiation;

the delivering device comprising an optical fiber optically coupled with an optical system, and a transverse scanning system for the low coherence optical radiation, the optical fiber being positioned to allow for the low coherence optical radiation to pass from the proximal end of the delivering device to its distal end, wherein the optical fiber is incorporated into the transverse scanning system, which is arranged capable of moving the end face of the distal part of the optical fiber over the transverse scanning surface in a direction approximately perpendicular to the own axis of the optical fiber;

wherein the optical system of the delivering device provides focusing the low coherence optical radiation onto the object and is designed having a quality of eliminating the transverse scanning related aberration of the optical length of the measuring arm, said optical system including at least a first lens component with positive focal power and at least a second lens component with positive focal power, which is positioned after the first lens component.

9. An apparatus as claimed in claim 8, wherein the transverse scanning surface has a non-zero curvature.

10. An apparatus as claimed in claim 9, wherein the optical fiber serves as a flexible cantilever and is fixedly attached to a bearing support incorporated into the delivering device for low coherence optical radiation.

11. An apparatus as claimed in claim 8, wherein the first and second lens components of the optical system are positioned substantially confocally.

12. An apparatus as claimed in claim 9, wherein the first lens component of the optical system is placed at a distance substantially equal to the focal length of the first lens component from the transverse scanning surface, while the distance between the first and second lens components of the optical system is diverse from that corresponding to a substantially confocal position of the lens components by a value δl , which is related with the focal length $F1$ of the first lens component and the radius of curvature R of the transverse scanning surface by the following relation:

$$\delta l \cong (F1)^2 / R.$$

13. An apparatus as claimed in claim 9, wherein the first lens component of the optical system is offset by a distance $\delta 2$ from the position at which the distance from the first lens component to the transverse scanning surface is substantially equal to the focal length $F1$ of the first lens component, while the distance between the first and second lens components of the optical system is diverse from the distance corresponding to the substantially confocal position of the lens components by a value $\delta 3$, which is given by the relation:

$$\delta 3 \cong (F1)^2 / (R + \delta 2).$$

14. An apparatus as claimed in claim 8, wherein the delivering device for low coherence optical radiation is designed as an optical fiber probe.

15. An apparatus as claimed in claim 8, wherein at least one interferometer arm is additionally provided with a device for longitudinal scanning.

16. An apparatus as claimed in claim 15, wherein the device for longitudinal scanning is placed in the measuring arm of the interferometer and is designed to provide altering the optical length of the part of the measuring arm located between the transverse scanning surface and the optical system.

17. An apparatus as claimed in claim 16, wherein when imaging a subsurface part of the object, the magnification factor M of the optical system is related to the refractive index $N1$ of the object as follows: $M = 1/N1$.

18. An apparatus as claimed in claim 16, wherein when imaging a profile of the object, the magnification factor M of the optical system is related to the refractive index $N2$ of the medium adjoining the surface of the object as follows: $M = 1/N2$.

19. An apparatus as claimed in claim 16, wherein the device for longitudinal scanning is placed within the delivering device for low coherence optical radiation.

20. An apparatus as claimed in claim 16, wherein the end face of the optical fiber is provided with a microlens, which is rigidly attached to the optical fiber.

21. A delivering device for low coherence optical radiation, comprising:

an optical fiber optically coupled with an optical system, and a transverse scanning system for the low coherence optical radiation;

the optical fiber being incorporated into the transverse scanning system and positioned to allow for low coherence optical radiation to pass from the proximal end of the delivering device to its distal end;

the transverse scanning system being arranged capable of moving the end face of the distal part of the optical fiber over a transverse scanning surface in a direction approximately perpendicular to the own axis of the optical fiber,

wherein the optical system includes at least a first lens component with positive focal power and at least a second lens component with positive focal power, which is positioned after the first lens component, said optical system providing focusing the low coherence optical radiation onto an object and being designed having a quality of eliminating the transverse scanning related aberration of the optical path length for the low coherence optical radiation passing through the delivering device.

22. A delivering device as claimed in claim 21, wherein the transverse scanning surface has a non-zero curvature.

23. A delivering device as claimed in claim 22, wherein the optical fiber serves as a flexible cantilever and is fixedly attached to a bearing support incorporated into the delivering device for low coherence optical radiation.

24. A delivering device as claimed in claim 21, wherein the first and second lens components of the optical system are positioned substantially confocally.

25. A delivering device as claimed in claim 22, wherein the first lens component of the optical system is placed at a distance substantially equal to the focal length of the first lens component from the transverse scanning surface, while the distance between the first and second lens components of the optical system is diverse from the distance corresponding to the substantially confocal position of the lens components by a value δl , which is related to the focal length $F1$ of the first lens component and the radius of curvature R of the transverse scanning surface by the following relation:

$$\delta l \cong (F1)^2 / R.$$

26. A delivering device as claimed in claim 22, wherein the first lens component of the optical system is offset by a distance $\delta 2$ from the position at which the distance from the first lens component to the transverse scanning surface is substantially equal to the focal length $F1$ of the first lens component, while the distance between the first and second lens components of the optical system is diverse from the distance corresponding to the substantially confocal position of the lens components by a value $\delta 3$, which is given by the relation:

$$\delta 3 \cong (F1)^2 / (R + \delta 2).$$

27. A delivering device as claimed in claim 21, wherein the delivering device for low coherence optical radiation is designed as an optical fiber probe, whereas the optical fiber, the optical system and the system for transverse scanning of low coherence radiation are encased into an elongated body with a throughhole extending therethrough, the optical fiber extending through the throughhole.

28. A delivering device as claimed in claim 21, wherein an output window of the delivering device for low coherence optical radiation is arranged near the image plane of the end face of the distal part of the optical fiber.

29. A delivering device as claimed in claim 28, wherein the second lens component of the optical system serves as the output window of the delivering device for low coherence optical radiation.

30. A delivering device as claimed in claim 28, wherein the normal line to the outer surface of the output window of the delivering device is oriented at an angle to the direction of incidence of the low coherence optical radiation on the outer surface, the angle exceeding the divergence angle of the low coherence optical radiation at the place of its intersection with the outer surface.

31. A delivering device as claimed in claim 30, wherein when using a one-coordinate substantially linear trajectory of transverse scanning the second lens component is offset both in a direction that is orthogonal to the direction of transverse scanning, and in a direction that is orthogonal to the direction of propagation of the low coherence optical radiation.

32. A delivering device as claimed in claim 21, wherein the delivering device is provided additionally with a device for longitudinal scanning designed as a device for altering the optical path length for the low coherence optical radiation propagating from the transverse scanning surface to the optical system.

33. A delivering device as claimed in claim 32, wherein when imaging a subsurface part of the object, the magnification factor M of the optical system is related to the refractive index $N1$ of the object as follows: $M = 1/N1$.

34. A delivering device as claimed in claim 32, wherein when imaging a profile of the object the magnification factor M of the optical system is related to the refractive index $N2$ of the medium adjoining the surface of the object as follows: $M = 1/N2$.

35. A delivering device as claimed in claim 21, wherein the end face of the optical fiber is provided with a microlens, which is rigidly attached to the optical fiber.